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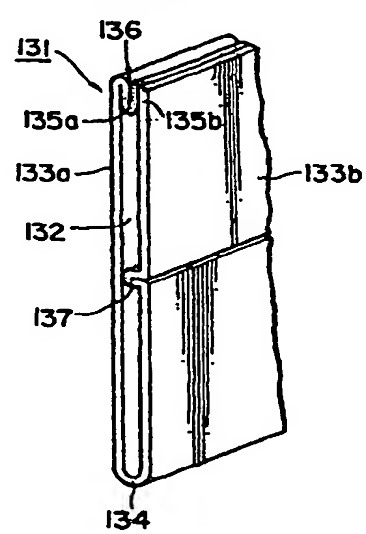
(54) HEAT EXCHANGER TUBE AND METHOD OF ITS MANUFACTURE

(57) A heat exchanger tube and a method for manufacturing the tube which has two flat plate portions provided to face each other and defining therebetween a passage for heat exchange medium; and a folded portion provided on at least one end portion in the widthwise direction of at least one flat plate portion, which is formed by folding the end portion so as to have a thickness which is an integral multiple of that of the plate forming the end portion. The folded portion and the corresponding end portion in the widthwise direction of the other flat plate portion are joined to each other. The obtained tube has such features that the junction strength of the joined portion is high enough to ensure high pressure resistance, that the internal dimensions of the tube may be changed easily and accurately, that flux may be sufficiently applied to portions required for brazing, and that a reinforced structure may be easily employed at the central portion in the widthwise direction of the tube.

FIG. 11



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Description

Technical Field of the Invention

[0001] The present invention relates to a heat exchanger tube and a method for manufacturing the same, and specifically to a heat exchanger tube suitable in use for heat exchangers for vehicles and a method for manufacturing it, and further, to a heat exchanger having the heat exchanger tube.

Background Art of the Invention

[0002] A heat exchanger tube, in more detail, a heat exchanger tube for flowing heat exchange medium in a heat exchanger, has been manufactured, for example, by bending a single flat plate material in the widthwise direction by roll bending, and joining tip portions of the end portions of the bent material to each other. In such a manufacturing method, for example, as shown in Fig. 27, a heat exchanger tube 301 is formed by abutting and joining the tip portions to each other at a junction 302. The tip portions are joined, for example, by electric-resistance welding.

[0003] In such a method as shown in Fig. 27, however, when an electro-unite tube formed by roll forming a single plate is used, because tip portions of the bent plate are welded at junction 302, the contact area is small and the strength for joining is low, and therefore, pressure resistance may be low. Further, because a long-sized material must be roll formed, the processing cost of tube 301 may increase. Moreover, because, in most cases, cutting to a predetermined length is carried out after processing in the roll forming of long-sized material, defective tubes may be produced, or correction after the manufacture may be required, and therefore, the cost for the manufacture may increase from this point of view. Furthermore, because only the tip portions of the bent plate are joined at junction 302, the internal dimensions of formed tube 301, in particular, the height of the fluid path, may be difficult to be accurately determined to a target dimension, and the dimension may be dispersed. Still further, if the target height of the fluid path is changed, it may be difficult to accurately follow the change.

[0004] Further, in a method for manufacturing a tube shown in Fig. 28, there are the following problems. In a heat exchanger having a core portion with tubes and fins disposed alternately, usually a method for heating and brazing the core portion at a condition of temporary assembly in a furnace is employed. However, as shown in Fig. 28, in the structure in that a joining portion 312 for forming a heat exchanger tube 311 is provided at a central portion in the widthwise direction of the tube, flux may not be applied sufficiently to the brazing portion, defect of brazing may occur, and a defective for sealing the heat exchange medium may be generated.

[0005] Moreover, in the structure in that joining portion 312 extending along tube 311 at a central portion in the widthwise direction of the tube is provided, as shown in Fig. 28, a high strength of tube 311 may be ensured. However, in the structure in that any projecting or abutting portion is not provided at a central portion in the widthwise direction of tube 301, as shown in Fig. 27, when the core portion is brazed, binding force may be applied to the core portion originating from the difference between the thermal expansion of the core portion and that of a jig for brazing (a jig for temporarily fixing the assembly of the core portion), and therefore, the tube may be deformed, or a defective of brazing (a defective for sealing) may be generated.

Disclosure of the Invention

[0006] Accordingly, an object of the present invention is to provide a heat exchanger tube and a method for manufacturing it, having such features that the junction strength of a joined portion of the heat exchanger tube is high enough to ensure sufficiently high pressure resistance, that the internal dimensions of the tube may be changed easily and accurately, that flux may be sufficiently applied to portions required for brazing, and that a reinforced structure may be easily employed at the central portion in the widthwise direction of the tube.

[0007] To achieve the foregoing object, a heat exchanger tube according to the present invention comprises two flat plate portions provided to face each other and defining therebetween a passage for heat exchange medium; and a folded portion provided on at least one end portion in the widthwise direction of at least one of the flat plate portions. The folded portion is formed by folding the end portion so as to have a thickness which is an integral multiple of a thickness of a plate forming the end portion, and the folded portion and a corresponding end portion in the widthwise direction of the other flat plate portion are joined to each other.

[0008] In the heat exchanger tube, a bent portion, which integrally connects two flat plate portions, may be formed at one end portion in the widthwise direction of the heat exchanger tube, the folded portion may be formed on each flat plate portion at the other end portion in the widthwise direction of the heat exchanger tube, and the respective folded portions may be joined to each other. Alternatively, the folded portion may be formed on each end portion in the widthwise direction of each flat plate portion, and each set of corresponding folded portions on the respective end portions may be joined to each other.

[0009] The folded portion may be formed by once folding at least one end portion in the widthwise direction of at least one flat plate portion, and the folded portion may be formed by plurally folding at least one end portion in the widthwise direction of at least one of the flat plate portions. In the case of the folded portion formed by plurally folding, the folded portion is formed, so that a

first folded piece portion comes into contact with an inner surface of a flat plate portion at a condition of surface contact, and a following folded piece portion comes into contact with a surface of a prior folded piece portion at a condition of surface contact. Such folded portions may be formed, for example, by pressing.

[0010] Further, the tube may be structured such that a projecting portion is formed at a central portion in the widthwise direction of one flat plate portion by bending the flat plate portion itself, and the projecting portion extends toward the other flat plate portion so as to substantially come into contact with the other flat plate portion. The above-described folded portion may be brazed to the corresponding end portion in the widthwise direction of the other flat plate portion.

[0011] To such a heat exchanger tube, the following structures may be added. For example, an inner fin may be provided between the flat plate portions. Further, a plurality of protruded portions protruding toward the inside of the tube may be provided on at least one of the flat plate portions, and protruded portions facing to each other, or, a protruded portion and an inner surface of a flat plate portion facing the protruded portion, may be abutted to each other. Further, the flat plate portions may be formed to expand toward outside of the tube so that a central portion in the widthwise direction of each flat portion is formed as a peak, thereby increasing the pressure resistance of the tube. Furthermore, grooves may be defined on an inner surface of each flat plate portion so that the grooves on one flat plate portion extend to intersect the grooves on the other flat plate portion.

[0012] A heat exchanger according to the present invention has such a heat exchanger tube. The type of the heat exchanger is not particularly restricted. For example, the present invention is applied to a heat exchanger wherein tubes and fins are alternately disposed.

[0013] A method for manufacturing a heat exchanger tube according to the present invention comprises the steps of (a) folding at least one end portion in the widthwise direction of a flat plate with a predetermined width to form a folded portion having a thickness which is an integral multiple of a thickness of the flat plate forming the end portion, (b) bending the flat plate at a central portion in the widthwise direction of the flat plate so that the folded portion is positioned inside, to form two flat plate portions defining therebetween a passage for heat exchange medium, and (c) joining the folded portion formed on at least one end portion of at least one of the flat plate portions to a corresponding end portion of the other flat plate portion.

[0014] Another method for manufacturing a heat exchanger tube according to the present invention comprises the steps of (a) folding both end portions in the widthwise direction of at least one flat plate of two flat plates having respective predetermined widths to form a folded portion at each end portion, the folded portion having a thickness which is an integral multiple of a thickness of the flat plate forming the end portion, and (b) joining the folded portions formed on both end portions of the flat plate and corresponding end portions of the other flat plate to each other.

[0015] Also in such manufacturing methods, the folded portion may be formed by once folding the end portion in the widthwise direction of the flat plate, and the folded portion may be formed by plurally folding. In the case of the folded portion formed by plurally folding, the folded portion is formed, so that a first folded piece portion comes into contact with an inner surface of a flat plate at a condition of surface contact, and a following folded piece portion comes into contact with a surface of a prior folded piece portion at a condition of surface contact. Such folded portions may be formed, for example, by pressing.

[0016] Further, before or after the folded portion is formed, a projecting portion may be formed at a central portion in the widthwise direction of one of flat plate portions forming the tube by bending the flat plate portion itself, so that the projecting portion is formed to extend toward the other flat plate portion so as to substantially come into contact with the other flat plate portion. The folded portion may be brazed to the corresponding end portion of a flat plate portion facing the folded portion.

[0017] The method for manufacturing a heat exchanger may have a step of providing an inner fin between two flat plate portions forming the tube. Further, a plurality of protruded portions protruding toward the inside of the tube may be formed on the flat plate when the tube is formed. Furthermore, grooves may be defined on surfaces of flat plate portions forming the tube so that the grooves on one flat plate portion extend to intersect the grooves on the other flat plate portion when the tube is formed.

[0018] In the heat exchanger tube and the method for manufacturing the same, the folded portion formed on the end portion in the widthwise direction of at least one flat plate portion can be formed, for example, by pressing. Therefore, the cost for the processing is cheap, and because a material having been cut at a predetermined width is pressed, defect of the processing does not occur and correction after the processing is not necessary. As a result, the cost for the manufacture may be greatly reduced.

[0019] Further, because tip portions are not joined to each other as in the conventional tubes but the folded portion can be joined to the end portion in the widthwise direction of the other flat plate portion at a condition of surface contact (this end portion may be formed as a folded portion), the junction area becomes sufficiently wide, a high junction strength may be ensured, and a high pressure resistance may be realized. Because the folded portion is formed by folding the plate once or a plurality of times so that the folded portion has a thickness of an integral multiple of the thickness of the plate forming the end portion in the widthwise direction of the

plate, and so that the folded piece portion is stacked at a condition of surface contact, a high strength of the folded portion itself may be ensured, as well as a high junction strength may be ensured by joined surfaces at a condition of surface contact, and a high pressure resistance may be achieved as the whole of the tube.

[0020] The thickness of the folded portion corresponds to a height of a fluid path formed in the tube. The thickness of the folded portion can be determined by the times of folding in the folded portion. Namely, the thickness of the folded portion, in particular, the thickness of the folded portion contributing decision of the internal dimensions of the tube, can be determined by the times of folding, that is, by the number of stacked folded piece portions, thereby greatly increasing the freedom of design. When plurally folded, or when folded piece portions are joined to each other, the thickness may be accurately determined as a dimension corresponding to a value of (the thickness of the folded piece portion x the number of the folded piece portions) by the surface contact between the folded piece portions or between the first folded piece portion and the inner surface of the flat plate portion having the first folded piece portion. Therefore, the internal dimensions of the tube to be formed may be accurately determined at target dimensions, thereby obtaining a tube with high accuracy.

[0021] When a projecting portion is provided, because the projecting portion can be formed by bending the flat plate portion itself, a portion requiring brazing is not generated at a central portion in the widthwise direction of the tube. Therefore, lack of flux, defect of brazing due to the lack of flux, and defect of sealing may not occur.

[0022] Further, when such a projecting portion is provided, while the above-described advantages are maintained, the tube may be reinforced at the central portion in the widthwise direction. Therefore, when the core portion is brazed, the deformation of the tube, defect of brazing originating from the difference between the thermal expansion of the core portion and that of a jig for brazing, and generation of a defective for sealing may be prevented.

Brief explanation of the drawing

[0023]

Fig. 1 is an elevational view of a heat exchanger according to an embodiment of the present invention.

Fig. 2 is a partial perspective view of a heat exchanger tube according to an embodiment of the present invention.

Fig. 3 is a partial perspective view of a heat exchanger tube according to another embodiment of the present invention.

Fig. 4 is a partial perspective view of a heat exchanger tube according to a further embodiment of the present invention.

Fig. 5 is a partial perspective view of a heat exchanger tube according to a still further embodiment of the present invention.

Fig. 6 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 2.

Fig. 7 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 3.

Fig. 8 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 4.

Fig. 9 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 5.

Fig. 10 shows partial perspective views of heat exchanger tubes according to still further embodiments of the present invention.

Fig. 11 is a partial perspective view of a heat exchanger tube according to a still further embodiment of the present invention.

Fig. 12 shows partial perspective views of heat exchanger tubes according to still further embodiments of the present invention.

Fig. 13 is a partial perspective view of a heat exchanger tube according to a still further embodiment of the present invention.

Fig. 14 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 10A.

Fig. 15 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 11.

Fig. 16 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 12A.

Fig. 17 is a process flow diagram showing a method for manufacturing the heat exchanger tube depicted in Fig. 13.

Fig. 18 is a partial perspective view of a heat exchanger tube according to a modification of the embodiment depicted in Fig. 2.

Fig. 19 is a partial perspective view of a heat exchanger tube according to a modification of the embodiment depicted in Fig. 10A.

Fig. 20A is a partial perspective view of a heat exchanger tube according to another modification of the embodiment depicted in Fig. 2, and Fig. 20B is a sectional view of the tube as viewed along the line XXB-XXB of Fig. 20A.

Fig. 21A is a partial perspective view of a heat exchanger tube according to another modification of the embodiment depicted in Fig. 10A, and Fig. 21B is a sectional view of the tube as viewed along the line XXIB-XXIB of Fig. 21A.

Fig. 22A is a partial perspective view of a heat exchanger tube according to a further modification of the embodiment depicted in Fig. 2, and Fig. 22B

is an enlarged elevational view of the tube depicted in Fig. 22A.

Fig. 23A is a partial perspective view of a heat exchanger tube according to a further modification of the embodiment depicted in Fig. 10A, and Fig. 23B is an enlarged elevational view of the tube depicted in Fig. 23A.

Fig. 24 is a partial plan view of a plate material before processed to the tube depicted in Fig. 22A or 23A.

Fig. 25 is a sectional view of a heat exchanger tube according to a still further modification of the embodiment depicted in Fig. 2.

Fig. 26 is a sectional view of a heat exchanger tube according to a still further modification of the embodiment depicted in Fig. 10A.

Fig. 27 is a partial perspective view of a conventional heat exchanger tube.

Fig. 28 is a partial perspective view of another conventional heat exchanger tube.

The Best mode for carrying out the Invention

[0024] Hereinafter, preferred embodiments of the present invention will be explained with reference to the drawings.

[0025] Fig. 1 depicts a heat exchanger 1 according to an embodiment of the present invention. Heat exchanger 1 has two tanks 2 and 3 provided at entrance and exit sides, a plurality of heat exchanger tubes 4 provided between tanks 2 and 3 for communicating between tanks 2 and 3 and each forming therein a passage for heat exchange medium, and corrugated fins 5. Heat exchanger tubes 4 and fins 5 are disposed alternately. In this embodiment, side plates 7 and 8 are provided on the outermost portions of a core portion 6 having heat exchanger tubes 4 and fins 5. Brackets 9 and 10 are attached to the outer surface of side plate 8 and the side surface of tank 2 for mounting heat exchanger 1. Fittings 11 and 12 for connecting pipes or other equipments are provided on tanks 2 and 3, respectively.

[0026] Such a heat exchanger tube 4 of heat exchanger 1 is constituted, for example, as shown in Figs. 2 to 5 or Figs. 10 to 13 (heat exchanger tubes 21, 31, 41, 51, 121a, 121b, 121c, 131, 141a, 141b, 141c and 151).

[0027] Heat exchanger tube 21 of the embodiment depicted in Fig. 2 comprises two flat plate portions 23a and 23b provided to face each other with a gap therebetween and defining therebetween a passage 22 for heat exchange medium; a bent portion 24 formed at one end portion in the widthwise direction of heat exchanger tube 21, which integrally connects two flat plate portions 23a and 23b; and folded portions 25a and 25b formed on the other end portions in the widthwise direction of respective flat plate portions 23a and 23b. Folded portions 25a and 25b are formed by bending by folding the respective end portions of flat plate portions 23a and 23b. Respective folded portions 25a and 25b are formed so that the inner surfaces of respective folded portions 25a and 25b come into contact with the surfaces of respective flat plate portions 23a and 23b positioned inside of the tube at a condition of surface contact, and so that the outer surfaces of folded portions 25a and 25b facing each other extend in parallel to each other. Folded portions 25a and 25b are formed by pressing. Folded portions 25a and 25b are joined to each other by brazing at a position of the parallel outer surfaces formed by folding (surfaces facing each other) (joining portion 26).

[0028] Heat exchanger tube 31 of the embodiment depicted in Fig. 3, similarly to that of the above-described heat exchanger tube 21, comprises two flat plate portions 33a and 33b defining a passage 32 for heat exchange medium; a bent portion 34 integrally connecting two flat plate portions 33a and 33b; and folded portions 35a and 35b formed on one end portion in the widthwise direction of each of flat plate portions 33a and 33b. Folded portions 35a and 35b are joined to each other by brazing at the outer surfaces formed by folding (joining portion 36). In this embodiment, a projecting portion 37 is formed at a central portion in the widthwise direction of one flat plate portion 33b by bending flat plate portion 33b itself so that projecting portion 37 extends toward the other flat plate portion 33a so as to substantially come into contact with the inner surface of flat plate portion 33a. The top surface of this projecting portion 37 may be joined to the inner surface of flat plate portion 33a, or may be merely brought into contact with the inner surface.

[0029] Heat exchanger tube 41 of the embodiment depicted in Fig. 4 comprises two flat plate portions 43a and 43b provided to face each other with a gap therebetween and defining therebetween a passage 42 for heat exchange medium; and folded portions 44a, 44b and 45a, 45b formed by bending and folding on both end portions in the widthwise direction of respective flat plate portions 43a and 43b. Corresponding folded portions 44a and 45a and folded portions 44b and 45b are joined to each other by brazing at a position of the outer surfaces formed by folding (joining portions 46a and 46b).

[0030] Heat exchanger tube 51 of the embodiment depicted in Fig. 5, similarly to that depicted in Fig. 4, comprises two flat plate portions 53a and 53b defining a passage 52 for heat exchange medium; and folded portions 54a, 54b and 55a, 55b formed on both end portions in the widthwise direction of respective flat plate portions 53a and 53b. Corresponding folded portions 54a and 55a and folded portions 54b and 55b are joined to each other by brazing at a position of the outer surfaces formed by folding (joining portions 56a and 56b). In this embodiment, a projecting portion 57 is formed at a central portion in the widthwise direction of one flat plate portion 53b by bending flat plate portion 53b itself

so that projecting portion 57 extends toward the other flat plate portion 53a so as to substantially come into contact with the inner surface of flat plate portion 53a. The top surface of this projecting portion 57 may be joined to the inner surface of flat plate portion 53a, or may be merely brought into contact with the inner surface.

[0031] Heat exchanger tubes 21, 31, 41 and 51 shown in Figs. 2 to 5 are manufactured by the methods shown in Figs. 6 to 9, respectively.

[0032] Fig. 6 shows a method for manufacturing heat exchanger tube 21 depicted in Fig. 2. First, a flat plate 63 having a predetermined width is formed by cutting a wide flat plate 61 prepared as a material for forming a tube, using an appropriate cutter 62. Then, both end portions in the widthwise direction of flat plate 63 with the predetermined width are bent to fold the end portions (in a direction of the upper surface side in Fig. 6), to form folded portions 25a and 25b on the respective end portions.

[0033] Next, flat plate 63 is bent at a central portion in the above-described direction (direction of the upper surface side in Fig. 6), and two flat plate portions 23a and 23b facing each other with a gap therebetween and defining therebetween passage 22 for heat exchange medium are formed. Then, folded portions 25a and 25b are joined to each other at a position of the outer surfaces formed by folding (joining portion 26), thereby completing heat exchanger tube 21 depicted in Fig. 2.

[0034] Fig. 7 shows a method for manufacturing heat exchanger tube 31 depicted in Fig. 3. First, a flat plate 71 having a predetermined width slightly larger than that shown in Fig. 6 is formed by cutting a wide flat plate 61 prepared as a material, using cutter 62. Then, projecting portion 37 is formed by bending flat plate 71 at a predetermined position thereof. Thereafter, both end portions in the widthwise direction of flat plate 71 are bent to fold the end portions in the same direction as that formed with projecting portion 37 to form folded portions 35a and 35b on the respective end portions. Next, flat plate 71 is bent at a central portion in the same surface-side direction to form bent portion 34, and two flat plate portions 33a and 33b facing each other with a gap therebetween and defining therebetween passage 32 for heat exchange medium are formed. Then, folded portions 35a and 35b are joined to each other at a position of the outer surfaces formed by folding (joining portion 36), thereby completing heat exchanger tube 31 depicted in Fig. 3.

[0035] Fig. 8 shows a method for manufacturing heat exchanger tube 41 depicted in Fig. 4. First, two flat plates 81a and 81b having an identical width are formed by cutting a wide flat plate 61 prepared as a material, using cutter 62. Then, folded portions 44a, 44b and 45a, 45b are formed by bending on both end portions of respective flat plates 81a and 81b. Flat plates 81a and 81b are formed as flat plate portions 43a and 43b. Flat plates 81a and 81b are positioned so that corresponding folded portions 44a and 45a and folded portions 44b and 45b face each other, and the corresponding folded portions 44a and 45a and folded portions 44b and 45b are joined to each other at positions of the outer surfaces formed by folding (joining portions 46a and 46b), thereby completing heat exchanger tube 41 having therein passage 42 for heat exchange medium depicted in Fig. 4.

[0036] Fig. 9 shows a method for manufacturing heat exchanger tube 51 depicted in Fig. 5. First, two flat plates 91a and 91b having different widths are formed by cutting a wide flat plate 61 prepared as a material, using cutter 62. Then, projecting portion 57 is formed by bending wider flat plate 91b at a central portion in the widthwise direction thereof. Folded portions 54a, 54b and 55a, 55b are formed by bending on both end portions of respective flat plates 91a and 91b. Flat plates 91a and 91b are formed as flat plate portions 53a and 53b. Flat plates 91a and 91b are positioned so that corresponding folded portions 54a and 55a and folded portions 54b and 55b face each other, and the corresponding folded portions 54a and 55a and folded portions 54b and 55b are joined to each other at positions of the outer surfaces formed by folding (joining portions 56a and 56b), thereby completing heat exchanger tube 51 having therein passage 52 for heat exchange medium depicted in Fig. 5.

[0037] In the heat exchanger tubes manufactured and constructed as described above, because the folded portions are joined to each other by brazing at the outer surfaces thereof, a sufficiently broad junction area may be obtained, and a high junction strength and a high pressure resistance for tubes can be achieved. Further, a fear of leakage may be solved. Therefore, a heat exchanger with a high performance can be realized.

[0038] Further, the folded portion formed on the end portion in the widthwise direction of each flat plate portion can be formed by pressing. Therefore, the conventional roll forming is not necessary, and great reduction of the cost for processing, the cost for manufacturing the tubes, ultimately, the cost for manufacturing the heat exchanger, may be achieved. Because roll forming is not carried out, correction after processing is also unnecessary, thereby greatly reducing generation of defectives, facilitating the manufacture and further reducing the cost for the manufacture.

[0039] Moreover, because a brazed portion does not exist at a central portion in the widthwise direction of the tube, there is no fear that flux does not extend sufficiently. Further, because the projecting portion for reinforcing the tube can be easily formed by bending one flat plate portion itself, a tube structure having a high strength can be easily achieved.

[0040] Besides, because the projecting portion basically is a portion which does not require flux flown from another portion or flux applied from outside, defect of application of flux, as in the structure shown in Fig. 27, does not occur. Therefore, generation of a defective for

brazing may be easily prevented.

[0041] Further, in the structure having the projecting portion, when core portion 6 is brazed while fixed with a jig, a high resistant force may be obtained against deforming force or shifting force originating from a difference between thermal expansions of the core portion and the jig. Consequently, the deformation of the tube and generation of defectives for brazing may be effectively prevented. Therefore, a high-performance heat exchanger with no leakage, which is properly brazed, may be manufactured.

[0042] In the explanation of the above-described methods, although the projecting portion is formed before formation of folded portions on the end portions, the projecting portion may be formed after formation of folded portions.

[0043] Next, heat exchanger tubes depicted in Figs 10 to 13 will be explained. In these tubes, a folded portion is formed by plurally folding at least one end portion in the widthwise direction of at least one flat plate portion so that the folded portion has a thickness which is an integral multiple of a thickness of a plate forming the end portion.

[0044] Heat exchanger tube 121a of the embodiment depicted in Fig. 10A comprises two flat plate portions 123a and 123b provided to face each other with a gap therebetween and defining therebetween a passage 122 for heat exchange medium; a bent portion 124 formed at one end portion in the widthwise direction of heat exchanger tube 121, which integrally connects two flat plate portions 123a and 123b; and a folded portion 125a formed on the other end portions in the widthwise direction of one flat plate portion 123a by folding the end portion plurally (in this embodiment, twice) in opposite directions. Folded portion 125a is joined to a corresponding end portion 125b of the other flat plate portion 123b (in this embodiment, a folded portion is not formed in this end portion) (joining portion 126). In folded portion 125a, a first folded piece portion 127a is folded so as to come into contact with the inner surface of flat plate portion 123a at a surface contact condition, and a second folded piece portion 127b is folded so as to come into contact with the prior folded piece portion 127a at a surface contact condition. Folded piece portion 127b of folded portion 125a is joined by brazing so as to come into contact with corresponding end portion 125b of the other flat plate portion 123b at a surface contact condition. Such a folded portion 125a is formed by pressing.

[0045] In heat exchanger tube 121b of the embodiment depicted in Fig. 10B, a folded portion 128 is formed on one end portion of the other flat plate portion 123b by folding the end portion once, and folded portion 125a and folded portion 128 are joined to each other by brazing so as to come into contact with each other at a surface contact condition. In heat exchanger tube 121c of the embodiment depicted in Fig. 10C, folded portions 125a are formed on corresponding end portions of both flat plate portions 123a and 123b, respectively, by folding each end portion twice, and folded portions 125a are joined to each other by brazing so as to come into contact with each other at a surface contact condition. Thus, the times of folding of a folded portion and the formation of the corresponding end portion of the other flat plate portion 123b may be arbitrarily chosen, and the internal dimension (the height of fluid path) may be determined accurately at a target dimension by determining the number of folded piece portions interposed between both flat plate portions 123a and 123b. Of course, an internal dimension other than those shown in figures may be determined, and according to target dimensions, the number of folded piece portions interposed between both flat plate portions 123a and 123b and the times of folding of the respective folded portions may be decided.

[0046] Heat exchanger tube 131 of the embodiment depicted in Fig. 11, similarly to that of the above-described heat exchanger tube 121a, comprises two flat plate portions 133a and 133b defining a passage 132 for heat exchange medium; a bent portion 134 integrally connecting two flat plate portions 133a and 133b; and folded portions 135a formed on the other end portions in the widthwise direction of one flat plate portion 133a by folding the end portion plurally (in this embodiment, twice) in opposite directions. Folded portion 135a is joined to a corresponding end portion 135b of the other flat plate portion 133b (in this embodiment, a folded portion is not formed in this end portion) (joining portion 136). In this embodiment, a projecting portion 137 is formed at a central portion in the widthwise direction of one flat plate portion 133b by bending flat plate portion 133b itself so that projecting portion 137 extends toward the other flat plate portion 133a so as to substantially come into contact with the inner surface of flat plate portion 133a. The top surface of this projecting portion 137 may be joined to the inner surface of flat plate portion 133a, or may be merely brought into contact with the inner surface. With respect to heat exchanger tubes 121b and 121c, similar structures may be employed.

[0047] Heat exchanger tube 141a of the embodiment depicted in Fig. 12A comprises two flat plate portions 143a and 143b (flat plates) provided to face each other with a gap therebetween and defining therebetween a passage 142 for heat exchange medium; and folded portions 144a and 144b formed by plurally bending and folding on both end portions in the widthwise direction of flat plate portion 143a. Folded portions 144a and 144b are joined by brazing to corresponding end portions 145a and 145b in the widthwise direction of the other flat plate portion 143b (joining portions 146a and 146b). In each of folded portions 144a and 144b, a first folded piece portion 147a is folded so as to come into contact with the inner surface of flat plate portion 143a at a surface contact condition, and a second folded piece portion 147b is folded so as to come into contact with the prior folded piece portion 147a at a surface contact con-

dition. Folded piece portion 147b of folded portions 144a and 144b are joined by brazing, respectively, so as to come into contact with corresponding end portions 145a and 145b of the other flat plate portion 143b at a surface contact condition. Such folded portions 144a and 144b are formed by pressing.

[0048] In heat exchanger tube 141b of the embodiment depicted in Fig. 12B, a folded portion 148 is formed on each end portion of the other flat plate portion 143b by folding the end portion once, and folded portion 144a, 144b and corresponding folded portions 148 are joined to each other by brazing so as to come into contact with each other at a surface contact condition. In heat exchanger tube 141c of the embodiment depicted in Fig. 12C, folded portion 144a and 144b are formed on corresponding end portions of both flat plate portions 143a and 143b, respectively, by folding each end portion twice, and the corresponding folded portions are joined to each other by brazing so as to come into contact with each other at a surface contact condition. Thus, even if the flat plate portions are separated before forming a tube, the times of folding of a folded portion and the formation of the corresponding end portion of the other flat plate portion 143b may be arbitrarily chosen, and the internal dimension (the height of fluid path) may be determined accurately at a target dimension by determining the number of folded piece portions interposed between both flat plate portions 143a and 143b. Of course, even in these embodiments, an internal dimension other than those shown in figures may be determined, and according to target dimensions, the number of folded piece portions interposed between both flat plate portions 143a and 143b and the times of folding of the respective folded portions may be decided.

[0049] Heat exchanger tube 151 of the embodiment depicted in Fig. 13, similarly to that shown in Fig. 12A, comprises two flat plate portions 153a and 153b defining a passage 152 for heat exchange medium; and folded portions 154a and 154b formed by plurally bending and folding on both end portions in the widthwise direction of flat plate portion 153a. Folded portions 154a and 154b are joined by brazing to corresponding end portions 155a and 155b in the widthwise direction of the other flat plate portion 153b (joining portions 156a and 156b). In this embodiment, a projecting portion 157 is formed at a central portion in the widthwise direction of one flat plate portion 153b by bending flat plate portion 153b itself so that projecting portion 157 extends toward the other flat plate portion 153a so as to substantially come into contact with the inner surface of flat plate portion 153a. The top surface of this projecting portion 157 may be joined to the inner surface of flat plate portion 153a, or may be merely brought into contact with the inner surface.

[0050] The heat exchanger tubes shown in Figs. 10 to 13 are manufactured as products of heat exchangers, generally, by assembling those together with other parts such as fins and header pipes and joining them by brazing in a furnace. As described later, an inner fin may be inserted into the tube for the purpose of increase of pressure resistance and heat transfer performance. In such a case, usually a clad material with a brazing material is used for any of fins and tube shells for joining by brazing. If a clad material with a brazing material on both surfaces is used, a tube shell may be brazed at a liquid sealing condition, and a bare material with no clad brazing material can be used for fins. Further, when only a tube shell is brazed, any of a method for using a material clad with a brazing material on both surfaces or on only one surface, or a method for using combination of these materials, may be appropriately selected.

[0051] Heat exchanger tubes 121a, 131, 141a and 151 shown in Figs. 10 to 13 are manufactured by the methods shown in Figs. 14 to 17, respectively. Heat exchanger tubes 121b, 121c, 141b and 141c may be manufactured by similar methods.

[0052] Fig. 14 shows a method for manufacturing heat exchanger tube 121a depicted in Fig. 10A. First, a flat plate 163 having a predetermined width is formed by cutting a wide flat plate 161 prepared as a material for forming a tube, using an appropriate cutter 162. Then, one end portion in the widthwise direction of flat plate 163 with the predetermined width is bent to fold the end portion twice to form folded portion 125a on the end portion.

[0053] Next, flat plate 163 is bent at a central portion in the widthwise direction in the direction of the upper surface side in Fig. 14 to form bent portion 124, and two flat plate portions 123a and 123b facing each other with a gap therebetween and defining therebetween passage 122 for heat exchange medium are formed. Then, folded portion 125a on the end portion of flat plate portion 123a and end portion 125b of flat plate portion 123b are joined to each other (joining portion 126), thereby completing heat exchanger tube 121a depicted in Fig. 10A.

[0054] Fig. 15 shows a method for manufacturing heat exchanger tube 131 depicted in Fig. 11. First, a flat plate 171 having a predetermined width slightly larger than that shown in Fig. 14 is formed by cutting a wide flat plate 161 prepared as a material, using cutter 162. Then, projecting portion 137 is formed by bending flat plate 171 at a predetermined position thereof. Thereafter, one end portion in the widthwise direction of flat plate 171 is bent to fold the end portion twice in the same direction as that formed with projecting portion 137 to form folded portion 135a on the end portion. Next, flat plate 171 is bent at a central portion in the same surface-side direction to form bent portion 134, and two flat plate portions 133a and 133b facing each other with a gap therebetween and defining therebetween passage 132 for heat exchange medium are formed. Then, folded portion 135a of the end portion of flat plate portion 133a and the end portion of flat plate portion 135b are joined to each other (joining portion

136), thereby completing heat exchanger tube 131 depicted in Fig. 11.

[0055] Fig. 16 shows a method for manufacturing heat exchanger tube 141a depicted in Fig. 12A. First, two flat plates 181a and 181b having different widths are formed by cutting a wide flat plate 161 prepared as a material, using cutter 162. Then, folded portions 144a and 144b are formed by bending on both end portions of one flat plate 181a. Flat plates 181a and 181b are formed as flat plate portions 143a and 143b. Flat plates 181a and 181b are positioned so that folded portions 144a and 144b and corresponding end portions 145a and 145b of flat plate 181b face each other, and they are joined to each other (joining portions 146a and 146b), thereby completing heat exchanger tube 141 having therein passage 142 for heat exchange medium formed by two flat plate portions 143a and 143b, depicted in Fig. 12A.

[0056] Fig. 17 shows a method for manufacturing heat exchanger tube 151 depicted in Fig. 13. First, two flat plates 191a and 191b are formed by cutting a wide flat plate 161 prepared as a material, using cutter 162. Then, projecting portion 157 is formed by bending one flat plate 191b at a central portion in the widthwise direction thereof. Folded portions 154a and 154b are formed on both end portions of the other flat plate 191a by plurally bending and folding the end portions. Folded portions 154a and 154b are joined to corresponding end portions 155a and 155b in the widthwise direction of the other flat plate 191b by brazing (joining portions 156a and 156b), thereby completing heat exchanger tube 151 having therein passage 152 for heat exchange medium depicted in Fig. 13.

[0057] In the heat exchanger tubes manufactured and constructed as described above, similarly in the aforementioned heat exchanger tubes shown in Figs. 2 to 5, because the folded portion formed on an end portions in the widthwise direction of at least one flat plate portion is joined to a corresponding end portion in the widthwise direction of the other flat plate portion at a condition of surface contact, without joining tip portions to each other as in the conventional tubes, a sufficiently broad junction area may be obtained, and a high junction strength and a high pressure resistance can be achieved. Because the folded portion is formed by plurally bending and folding the end portion in opposite directions and the folded piece portions are formed to be stacked at a condition of surface contact, a high strength may be ensured with respect to the folded portion itself as well as a high junction strength may be ensured by the above-described surface contact condition, thereby realizing a further high pressure resistance as the whole of the tube.

[0058] Further, because the folded portion formed on the end portion in the widthwise direction of the flat plate portion can be formed by pressing, the conventional roll forming is not necessary, and great reduction of the cost for processing, the cost for manufacturing the tubes, ultimately, the cost for manufacturing the heat exchanger, may be achieved. Because roll forming is not carried out, correction after processing is also unnecessary, thereby greatly reducing generation of defectives, facilitating the manufacture and further reducing the cost for the manufacture.

[0059] Moreover, the folded portion is formed by plurally bending and folding the end portion in opposite directions, and the internal dimensions of the tube may be determined substantially freely and accurately by the times of folding, and therefore, the freedom of design may be greatly increased. The internal dimension of the tube may be determined at a dimension corresponding to a value of (the thickness of the folded piece portion x the number of the folded piece portions) more accurately by bringing the first folded piece portion into contact with the inner surface of the flat plate portion at a condition of surface contact. Therefore, the internal dimensions of the tube may be determined at target dimensions at high accuracy, thereby easily achieving a tube with desired internal dimensions.

[0060] Further, because a brazed portion does not exist at a central portion in the widthwise direction of the tube, there is no fear that flux does not extend sufficiently. Further, because the projecting portion for reinforcing the tube can be easily formed by bending one flat plate portion itself, a tube structure having a high strength can be easily realized.

[0061] Besides, because the projecting portion basically is a portion which does not require flux flown from another portion or flux applied from outside, defect of application of flux, as in the structure shown in Fig. 27, does not occur. Therefore, generation of a defective for brazing may be easily prevented.

[0062] Further, in the structure having the projecting portion, when core portion 6 is brazed while fixed with a jig, a high resistant force may be obtained against deforming force or shifting force originating from a difference between thermal expansions of the core portion and the jig. Consequently, the deformation of the tube and generation of defectives for brazing may be effectively prevented. Therefore, a high-performance heat exchanger with no leakage, which is properly brazed, may be manufactured.

[0063] In the explanation of the above-described methods, although the projecting portion is formed before formation of folded portions on the end portions, the projecting portion may be formed after formation of folded portions.

[0064] The heat exchanger tubes depicted in Figs. 2 to 5 and Figs. 10 to 13 may have the following additional structures. Although the additional structures will be explained as to the heat exchanger tubes depicted in Fig. 2 and Fig. 10A, these structures may similarly be applied to the tubes depicted in Figs. 3 to 5, Figs. 10B and 10C, and Figs. 11 to 13.

[0065] In heat exchanger tube 201 depicted in Figs. 18 and 19, an inner fin 204 formed as a wave type is

provided in a passage 203 for heat exchange medium defined between flat plate portions 202a and 202b of tube 201, and the passage 203 is divided into a plurality of paths by inner fin 204. The structure of inner fin 204 is not particularly limited, and a structure other than the wave type may be employed. Such an inner fin 204 may be inserted after forming tube 201.

[0066] In heat exchanger tube 201 having such a structure, in addition to the operation and advantages that have been explained in the embodiment shown in Fig. 2 or 10A, uniformity of the temperature of tube 201 may be achieved, and the performance of heat exchange by tube 201 may be further increased.

[0067] In heat exchanger tube 211 depicted in Figs. 20A, 20B and Figs. 21A, 21B, a plurality of protruded portions 213 protruding toward the inside of the tube are provided on both flat plate portions 212a and 212b of tube 211, and protruded portions 213 are disposed to face each other and the top surfaces thereof are brought into contact with each other. Respective protruded portions 213 may be formed easily by embossing a flat plate material before forming the tube, and the tube may be processed after forming the protruded portions 213.

[0068] In heat exchanger tube 211 having such a structure, in addition to the operation and advantages that have been explained in the embodiment shown in Fig. 2 or 10A, because the mixing performance for the heat exchange medium flowing in the passage may be improved by protruded portions 213, uniformity of the temperature and acceleration of heat transfer may be achieved, and the performance of heat exchange by tube 211 may be further increased.

[0069] Protruded portions 213 may be provided on only one flat plate portion, and the top surfaces of the protruded portions 213 may be brought into contact with the inner surface of the other flat plate portion facing the protruded portions 213.

[0070] In heat exchanger tube 221 depicted in Figs. 22A, 22B and Figs. 23A, 23B, a plurality of grooves 223a and 223b extending obliquely in the directions to intersect each other are defined on flat plate portions 222a and 222b, respectively. For example, as shown in Fig. 24, these grooves 223a and 223b are defined on a flat plate material 224 before forming tube 221 so that the grooves extend to intersect each other when tube 221 is formed and thereafter, the material may be processed into tube 221.

[0071] In heat exchanger tube 221 having such a structure, in addition to the operation and advantages that have been explained in the embodiment shown in Fig. 2 or 10A, because the mixing performance for the heat exchange medium flowing in the passage may be improved by intersecting grooves 223a and 223b, uniformity of the temperature and acceleration of heat transfer may be achieved, and the performance of heat exchange by tube 221 may be further increased.

[0072] Further, in the present invention, as shown in Figs. 25 and 26, a tube 231 may be formed to have flat plate portions 232a and 232b expanding outside of the tube so that a central portion in the widthwise direction of each flat portion is formed as a peak. In such a structure, the pressure resistance of tube 231 may be increased. The amount of the expansion " δ " may be fairly small.

[0073] The application of the heat exchanger tube according to the present invention is not limited to the heat exchanger such as the type depicted in Fig. 1, but it may be applied to any type of heat exchanger. In particular, it may be suitable for use in a heat exchanger for vehicles, for example, a radiator, and a heater, a condenser and an evaporator for air conditioners for vehicles, and an intercooler.

<u>Industrial Applications of the Invention</u>

[0074] According to the present invention, a heat exchanger tube high in junction strength and pressure resistance and high in freedom of design can be manufactured easily and inexpensively. Further, defect of brazing due to defect of the application of flux may be prevented, and the strength of the tube against deformation may be increased by forming the projecting portion, etc. Therefore, such an excellent heat exchanger tube may be extremely useful to a heat exchanger for vehicles.

Claims

1. A heat exchanger tube comprising:

    two flat plate portions provided to face each other and defining therebetween a passage for heat exchange medium; and
    a folded portion provided on at least one end portion in the widthwise direction of at least one of said flat plate portions, said folded portion being formed by folding said end portion so as to have a thickness which is an integral multiple of a thickness of a plate forming said end portion, said folded portion and a corresponding end portion in the widthwise direction of the other flat plate portion being joined to each other.

2. The heat exchanger tube according to claim 1, wherein a bent portion, which integrally connects said two flat plate portions, is formed at one end portion in the widthwise direction of said heat exchanger tube, said folded portion is formed on each flat plate portion at the other end portion in the widthwise direction of said heat exchanger tube, and the respective folded portions are joined to each other.

3. The heat exchanger tube according to claim 1,

wherein said folded portion is formed on each end portion in the widthwise direction of each flat plate portion, and each set of corresponding folded portions on the respective end portions are joined to each other.

4. The heat exchanger tube according to any of claims 1 to 3, wherein said folded portion is formed by plurally folding at least one end portion in the widthwise direction of at least one of said flat plate portions.

5. The heat exchanger tube according to claim 4, wherein said folded portion is formed, so that a first folded piece portion comes into contact with an inner surface of a flat plate portion at a condition of surface contact, and a following folded piece portion comes into contact with a surface of a prior folded piece portion at a condition of surface contact.

6. The heat exchanger tube according to claim 1, wherein said folded portion is formed by pressing.

7. The heat exchanger tube according to claim 1, wherein a projecting portion is formed at a central portion in the widthwise direction of one flat plate portion by bending the flat plate portion itself, and said projecting portion extends toward the other flat plate portion so as to substantially come into contact with the other flat plate portion.

8. The heat exchanger tube according to claim 1, wherein said folded portion is brazed to said corresponding end portion in the widthwise direction of the other flat plate portion.

9. The heat exchanger tube according to claim 1, wherein an inner fin is provided between said flat plate portions.

10. The heat exchanger tube according to claim 1, wherein a plurality of protruded portions protruding toward the inside of the tube are provided on at least one of said flat plate portions, and protruded portions facing to each other, or, a protruded portion and an inner surface of a flat plate portion facing the protruded portion, are abutted to each other.

11. The heat exchanger tube according to claim 1, wherein grooves are defined on an inner surface of each flat plate portion, and the grooves on one flat plate portion extend to intersect the grooves on the other flat plate portion.

12. The heat exchanger tube according to claim 1, wherein said flat plate portions expand outside of the tube so that a central portion in the widthwise direction of each flat portion is formed as a peak.

13. A heat exchanger having said heat exchanger tube according to any of claims 1 to 12.

14. The heat exchanger according to claim 13, wherein said tube and a fin are alternately disposed.

15. A method for manufacturing a heat exchanger tube comprising the steps of:

(a) folding at least one end portion in the widthwise direction of a flat plate with a predetermined width to form a folded portion having a thickness which is an integral multiple of a thickness of said flat plate forming said end portion;
(b) bending said flat plate at a central portion in the widthwise direction of said flat plate so that said folded portion is positioned inside, to form two flat plate portions defining therebetween a passage for heat exchange medium; and
(c) joining said folded portion formed on at least one end portion of at least one of said flat plate portions to a corresponding end portion of the other flat plate portion.

16. A method for manufacturing a heat exchanger tube comprising the steps of:

(a) folding both end portions in the widthwise direction of at least one flat plate of two flat plates having respective predetermined widths to form a folded portion at each end portion, said folded portion having a thickness which is an integral multiple of a thickness of said flat plate forming said end portion; and
(b) joining said folded portions formed on both end portions of said flat plate and corresponding end portions of the other flat plate to each other.

17. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein said folded portion is formed by plurally folding said end portion in the widthwise direction of said flat plate.

18. The method for manufacturing a heat exchanger tube according to claim 17, wherein said folded portion is formed, so that a first folded piece portion comes into contact with an inner surface of said flat at a condition of surface contact, and a following folded piece portion comes into contact with a surface of a prior folded piece portion at a condition of surface contact.

19. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein said

folded portion is formed by pressing.

20. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein a projecting portion is formed at a central portion in the widthwise direction of one of flat plate portions forming the tube by bending the flat plate portion itself, and said projecting portion is formed to extend toward the other flat plate portion so as to substantially come into contact with the other flat plate portion.

21. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein said folded portion is brazed to said corresponding end portion of a flat plate portion facing said folded portion.

22. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein an inner fin is provided between two flat plate portions forming the tube.

23. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein a plurality of protruded portions protruding toward the inside of the tube are formed on said flat plate when the tube is formed.

24. The method for manufacturing a heat exchanger tube according to claim 15 or 16, wherein grooves are defined on surfaces of flat plate portions forming the tube so that the grooves on one flat plate portion extend to intersect the grooves on the other flat plate portion when the tube is formed.

FIG. 1

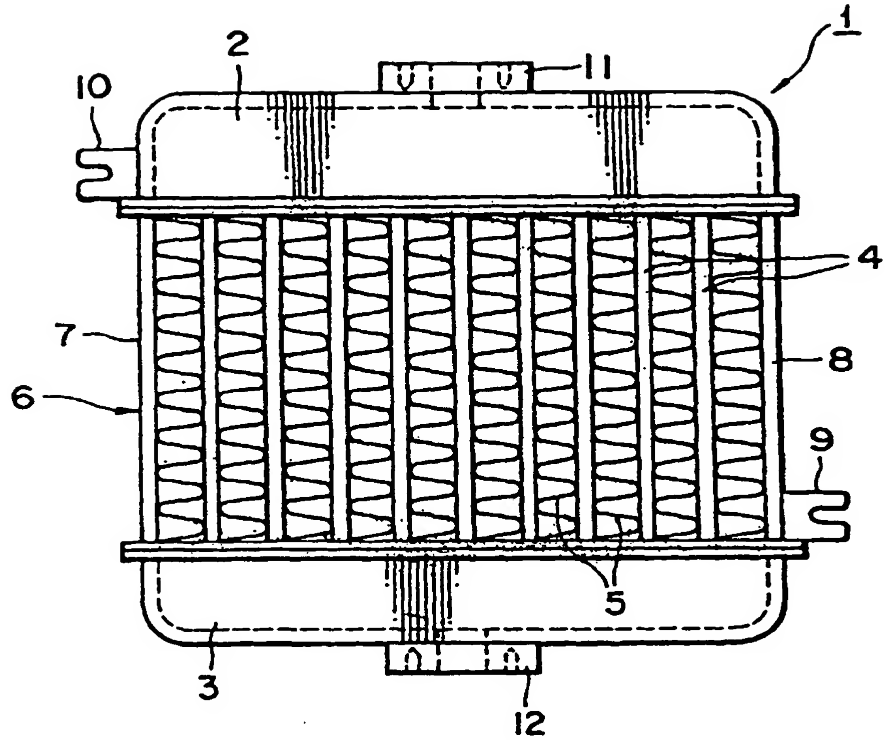


FIG. 2

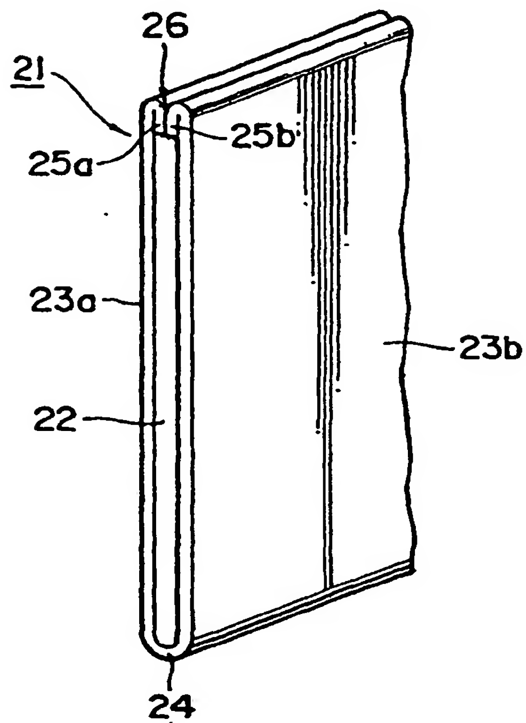


FIG. 3

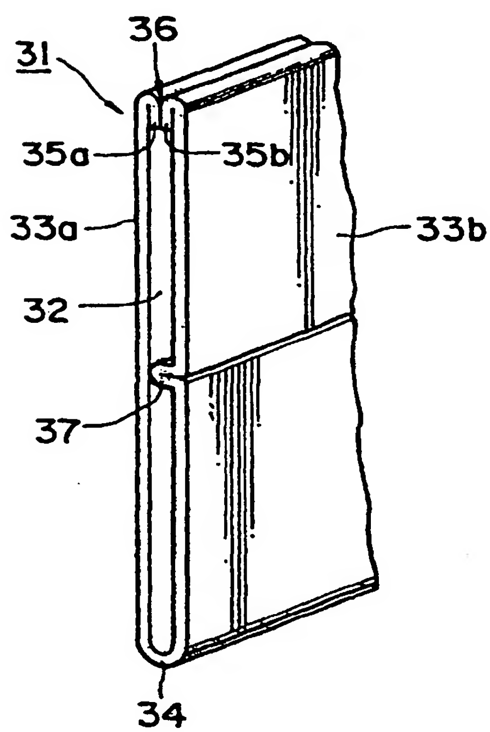


FIG. 4

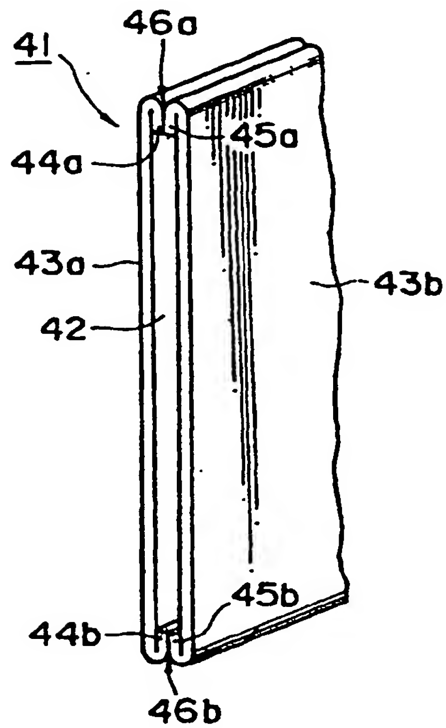

41
46a
45a
44a
43a
43b
42
45b
44b
46b

FIG. 5

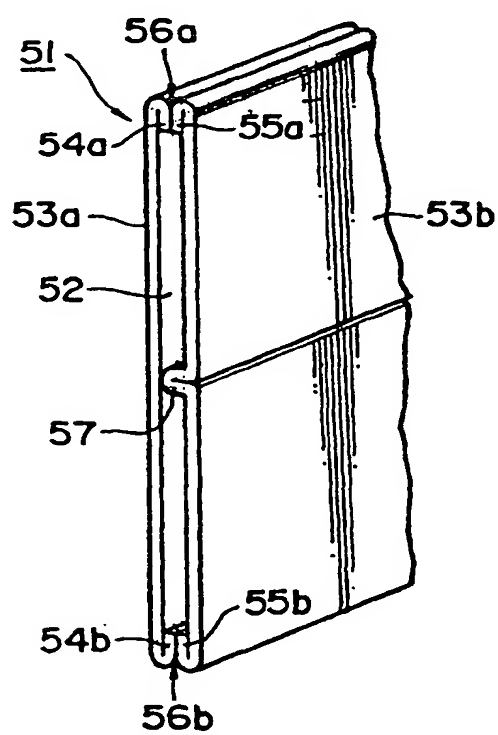

51
56a
55a
54a
53a
53b
52
57
55b
54b
56b

FIG. 6

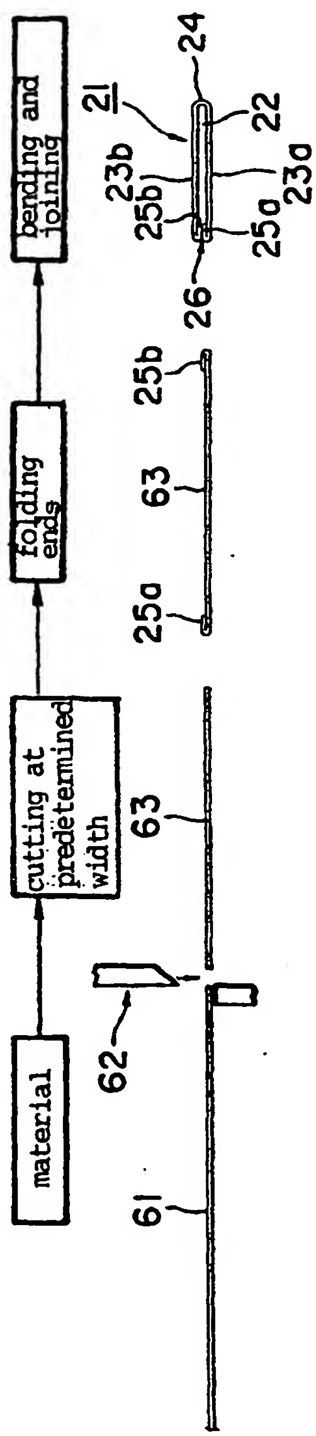

material
cutting at predetermined width
folding ends
bending and joining
61
62
63
63
25a
25b
26
25b
25a
23b
23a
22
24
21

FIG. 7

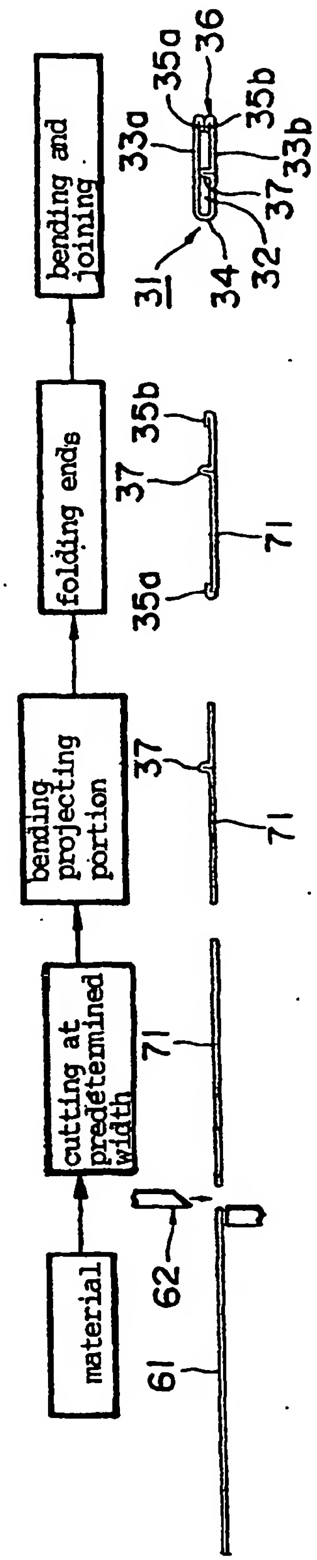

material
cutting at predetermined width
bending projecting portion
folding ends
bending and joining
61
62
71
71
37
71
35a
37
35b
31
34
32
37
33a
33b
35a
35b
36

FIG. 8

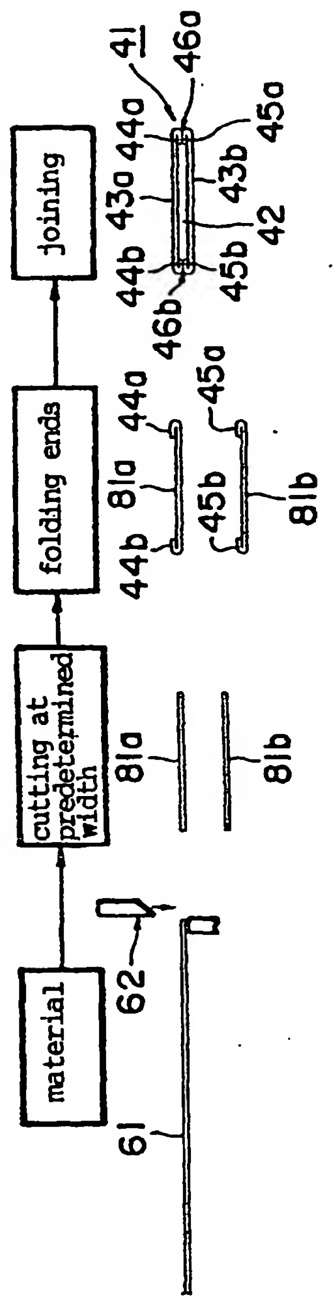

material
cutting at predetermined width
folding ends
joining
61
62
81a
81b
44a
44b
45a
45b
41
42
43a
43b
46a
46b

FIG. 9

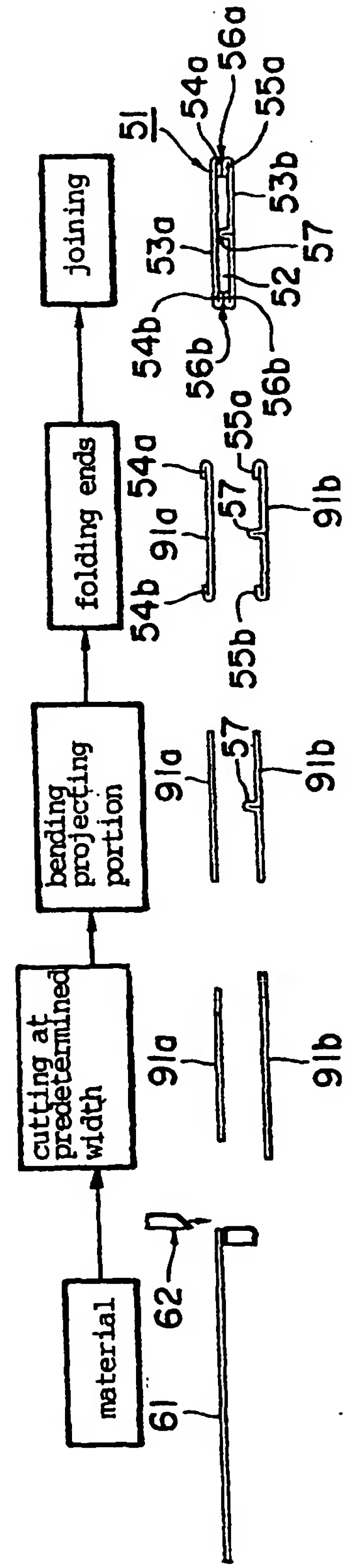

material
cutting at predetermined width
bending projecting portion
folding ends
joining
61
62
91a
91b
57
54a
54b
55a
55b
51
52
53a
53b
56a
56b

FIG. 10A

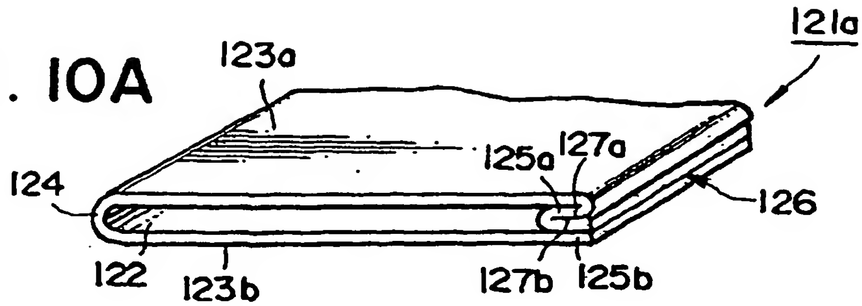


FIG. 10B

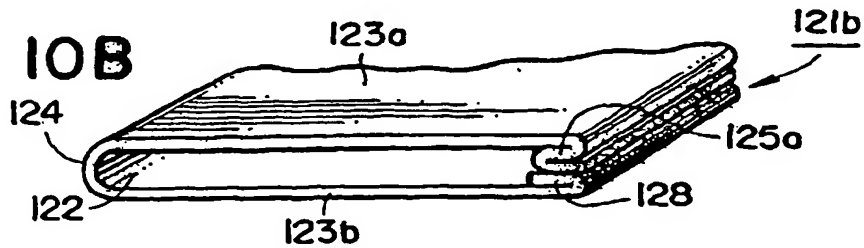


FIG. 10C

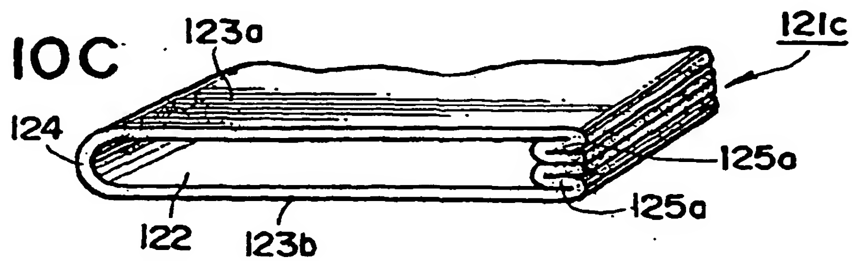


FIG. 11

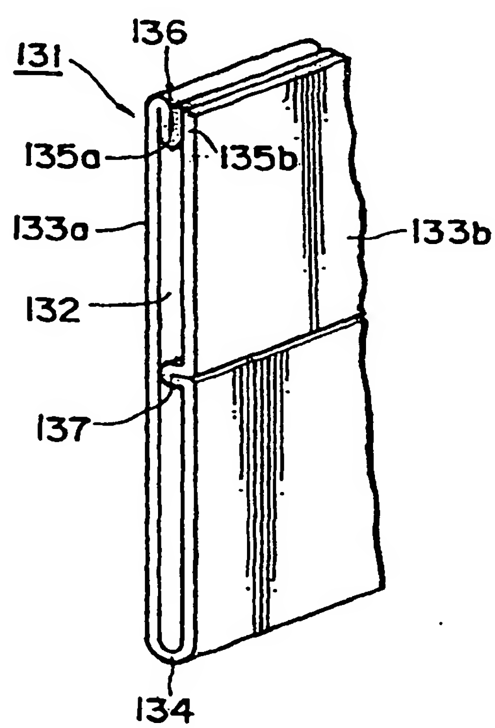


FIG. 12A

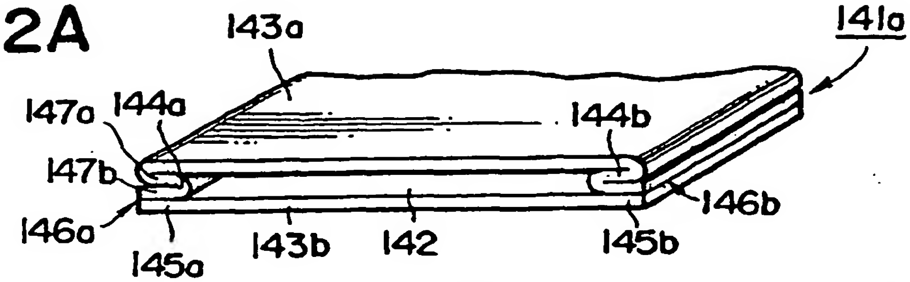


FIG. 12B

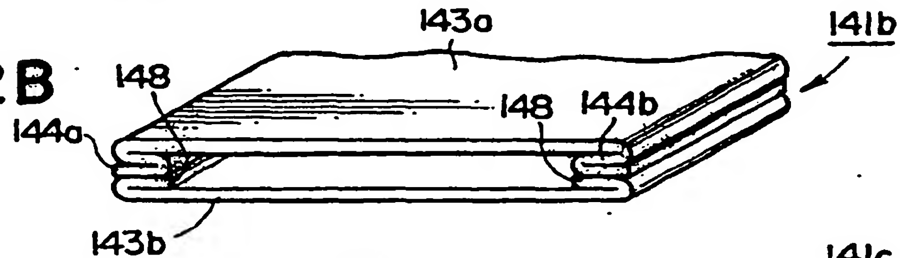


FIG. 12C

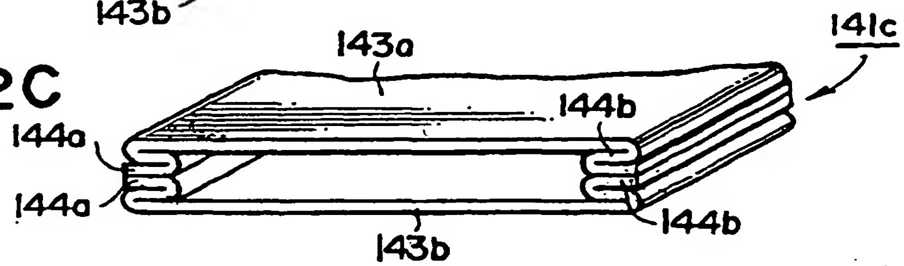


FIG. 13

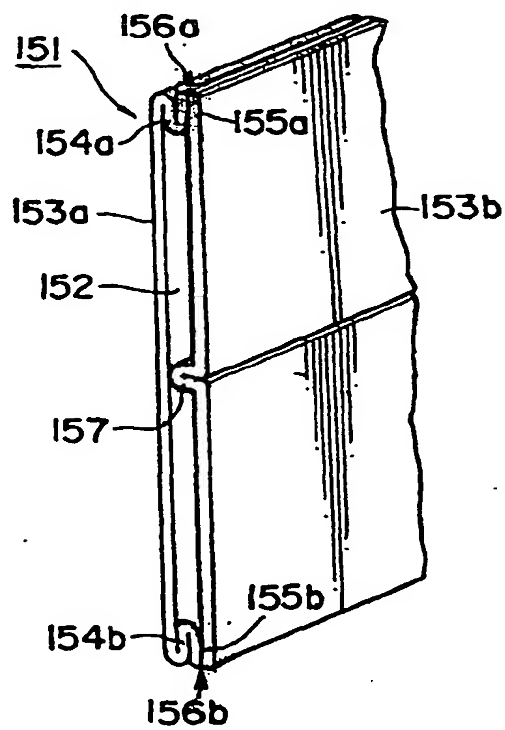


FIG. 14

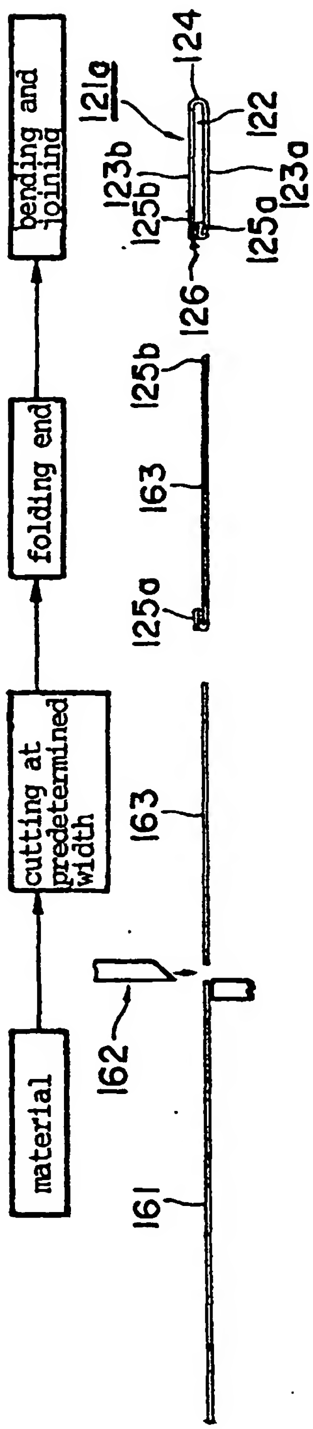

material
cutting at predetermined width
folding end
bending and joining
161
162
163
125a
125b
121a
122
123a
123b
124
126

FIG. 15

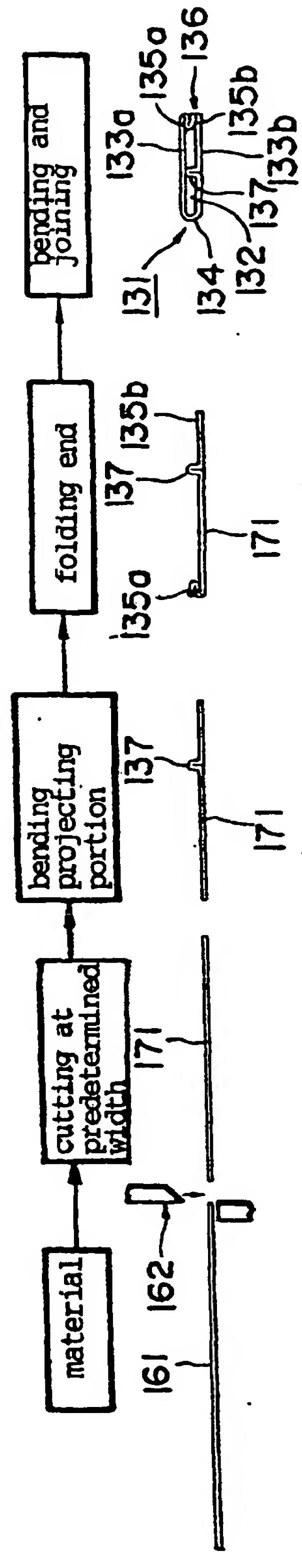

material
cutting at predetermined width
bending projecting portion
folding end
bending and joining
161
162
171
137
135a
135b
131
132
133a
133b
134
136

FIG. 16

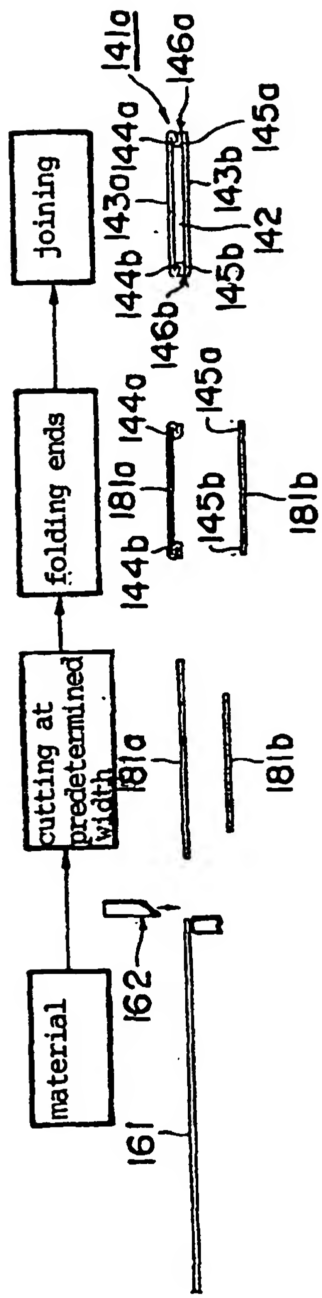

material
cutting at predetermined width
folding ends
joining
161
162
181a
181b
144a
144b
145a
145b
141a
142
143a
143b
146a
146b

FIG. 17

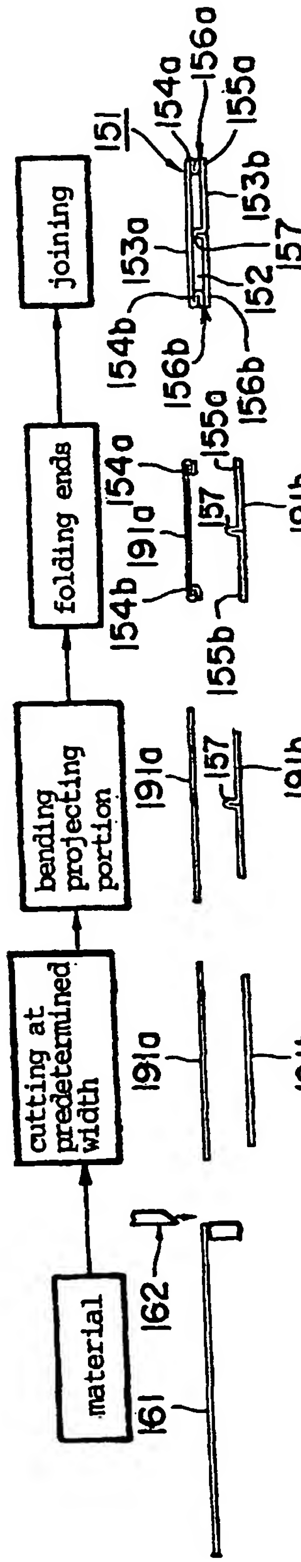

material
cutting at predetermined width
bending projecting portion
folding ends
joining
161
162
191a
191b
157
154a
154b
155a
155b
151
152
153a
153b
156a
156b

FIG. 18

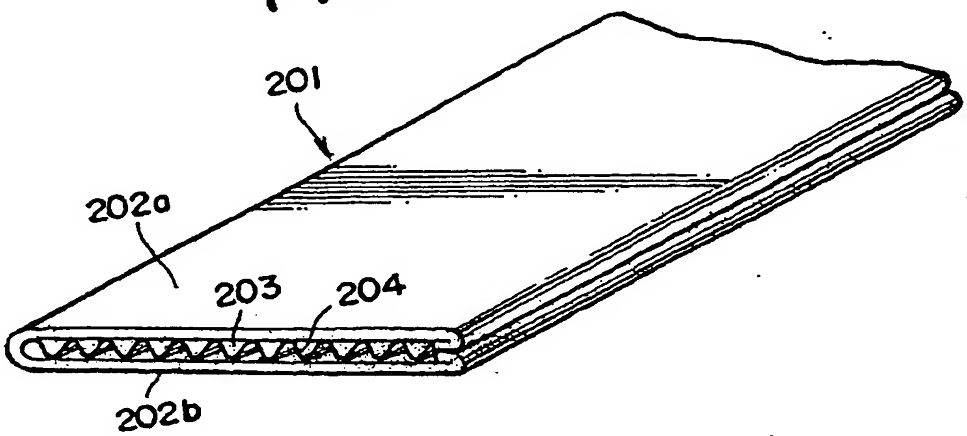


FIG. 19

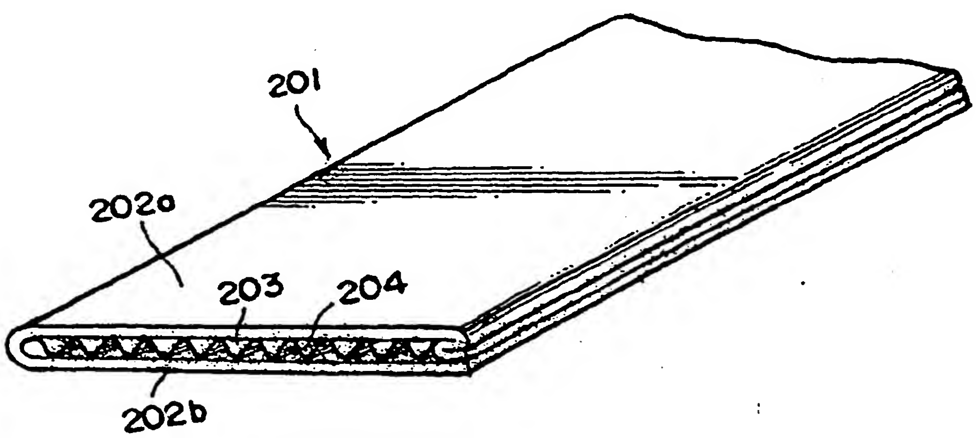


FIG. 20A

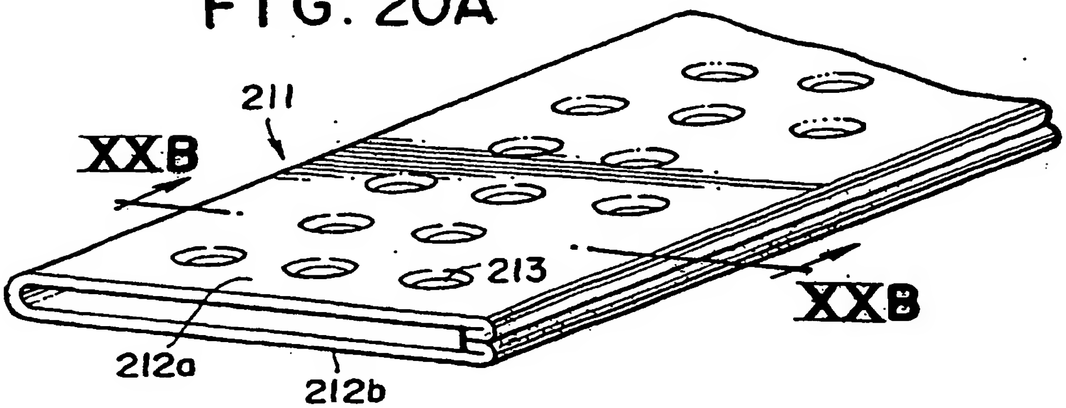


FIG. 20B

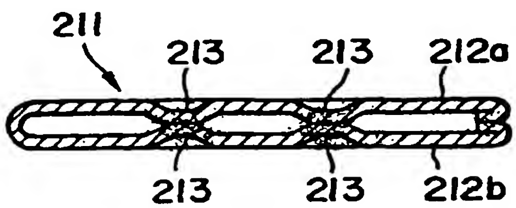


FIG. 21A

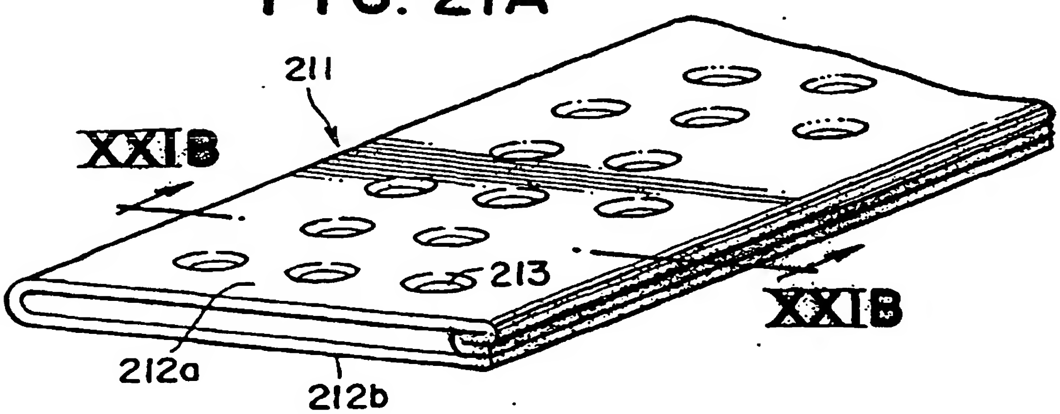


FIG. 21B

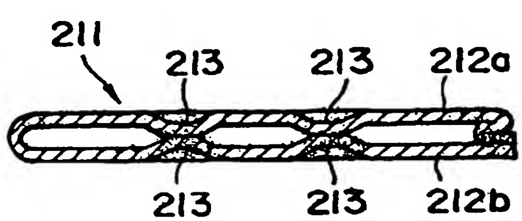


FIG. 22A

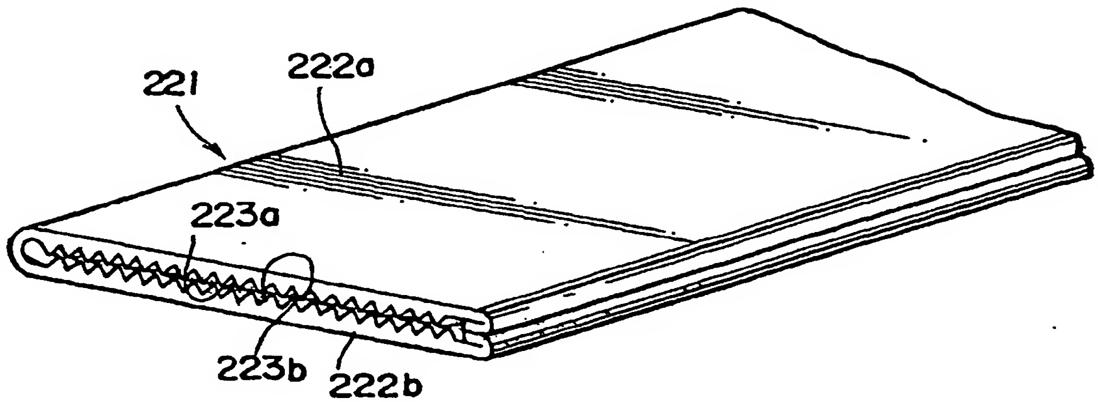


FIG. 22B

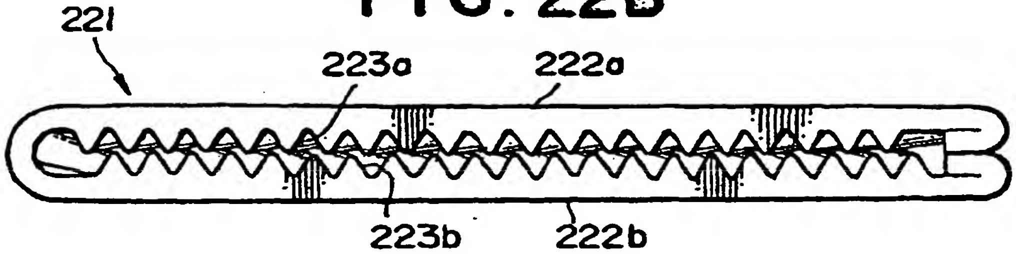


FIG. 23A

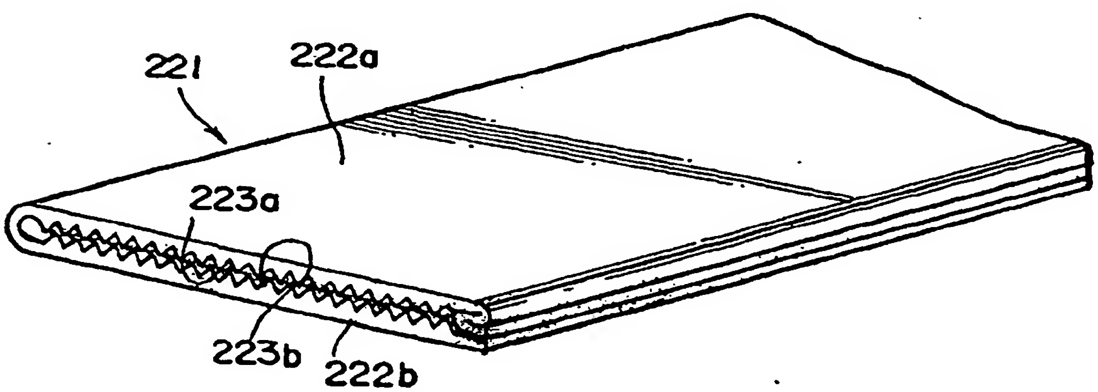


FIG. 23B

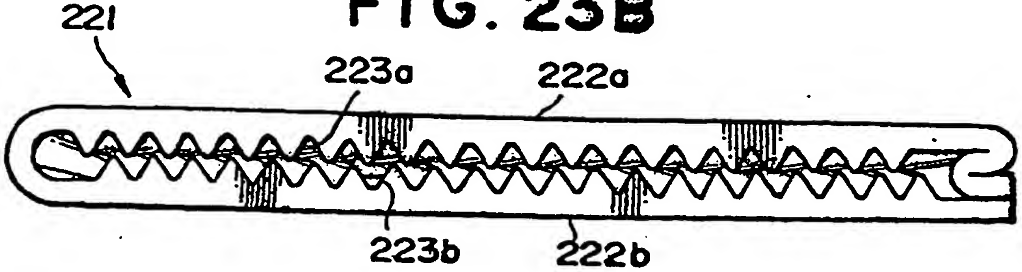


FIG. 24

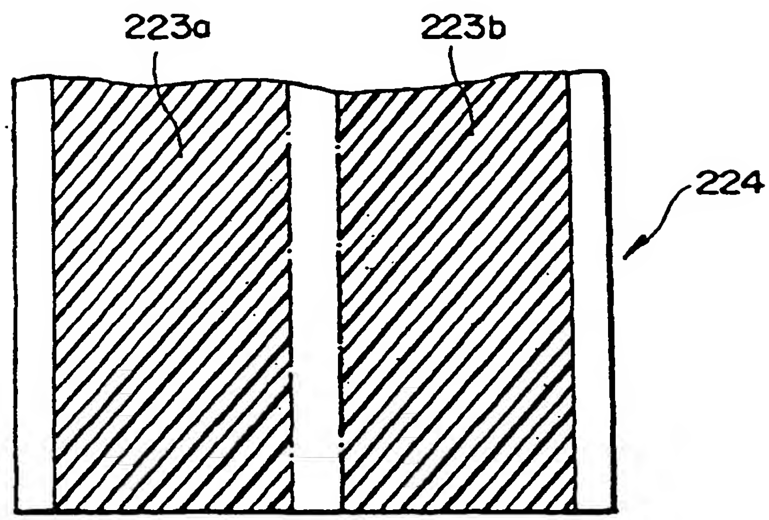


FIG. 25

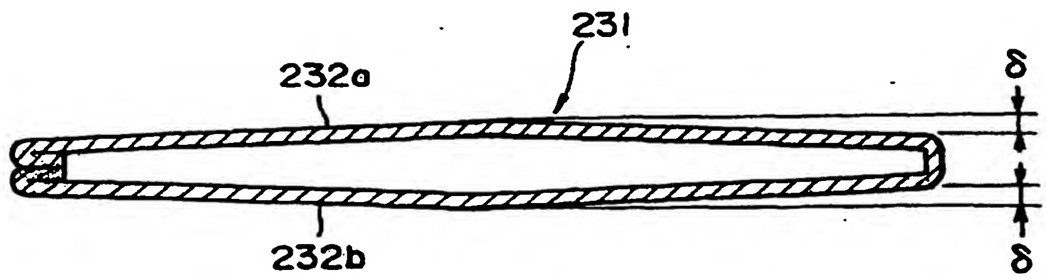


FIG. 26

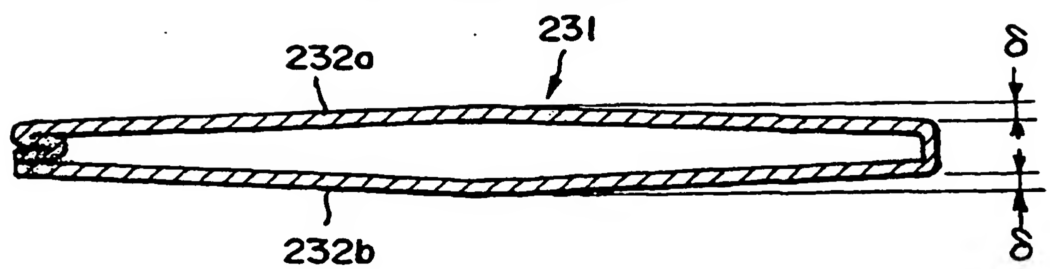


FIG. 27

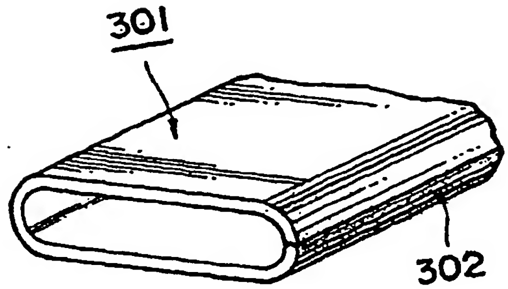
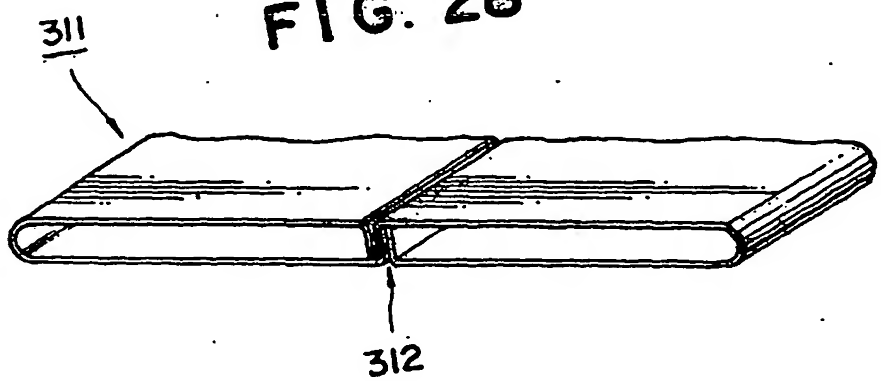


FIG. 28



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/01370

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] F28F1/02, 1/40, B21D53/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] F28F1/02, 1/40, B21D53/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1998 Toroku Jitsuyo Shinan Koho 1994-1998
Kokai Jitsuyo Shinan Koho 1971-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP, 4-86489, A (Showa Aluminium Corp.), March 19, 1992 (19. 03. 92) & US, 5386629, A & EP, 457470, A1	1-3, 6-9, 13-16, 19-22 4, 10-12, 17, 23, 24
Y	JP, 61-66091, A (Toyo Radiator Co., Ltd.), April 4, 1986 (04. 04. 86) (Family: none)	4, 17
Y	JP, 59-125395, A (Showa Aluminium Corp.), July 19, 1984 (19. 07. 84) (Family: none)	10, 23
Y	JP, 8-226784, A (Sanden Corp.), September 3, 1996 (03. 09. 96) (Family: none)	11, 24
Y	JP, 7-77397, A (Kawaju Reinetsu Kogyo K.K.), March 20, 1995 (20. 03. 95) (Family: none)	12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
June 23, 1998 (23. 06. 98)	July 7, 1998 (07. 07. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)